Instruction Manual

JOHN FLUKE MFG. CO., INC.

ELECTRONICS FOR INDUSTRY

Model 801H
DC DIFFERENTIAL
VOLTMETER

INSTRUMENTS / COMPONENTS

John Fluke Mfg. Co., Inc.
P.O. Box 7428 Seattle 33, Washington

Model 801H
DC DIFFERENTIAL
VOLTMETER

Serial No. 380 and above

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SECTION 1

SPECIFICATIONS

1-1 CONVENTIONAL VTVM SPECIFICATIONS

RANGES	INPUT R	SCALES	*RANGES	INPUT R	SCALES
0 to ±500 V	10 megohms	500-0-500	0 to ± 10 V	10 megohms	10-0-10
0 to ± 50 V	10 megohms	50-0-50	0 to ± 1 V	10 megohms	1-0-1
0 to ± 5 V	10 megohms	5-0-5	0 to ± 0.1 V	10 megohms	0.1-0-0.1
0 to ±0.5 V	10 megohms	0.5-0-0.5	0 to ± 0.01 V	1 megohms	0.01-0-0.01
			0 to ±0.001 V	1 megohms	0.001-0-0.001

ACCURACY: 3% on all ranges. *These ranges obtained by setting NULL knob to desired sensitivity with 5 voltage knobs set to 0.

1-2 PRECISION POTENTIOMETER SPECIFICATIONS

INPUT	RANGE SETTING	*NULL SETTING		INPUT RESISTANCE (RES. PER VOLT OF INPUT) AT NULL	AT 1% OFF NULL	
50-500	0-500	10-0-10	1-0-1	Inf.	100 meg	1,000 meg
5-50	0-50	1-0-1	0.1-0-0.1	Inf.	1,000 "	10,000 "
0.5-5	0-5	0.1-0-0.1	0.01-0-0.01	Inf.	10,000 "	10,000 "
0-0.5	0-0.5	0.01-0-0.01	0.001-0-0.001	Inf.	10,000 "	100,000 "

*Recommended null range. Any null range may be used at any input voltage; recommended ranges are those most useful.

ACCURACY: ±0.05% of input voltage from 0.1 V to 500 V.
±0.1% of input voltage or ±0.05 mv, whichever is greater below 0.1 V.
These accuracies obtained when recommended ranges are used.

RESOLUTION:

RANGE	DIRECT VIA DIALS		MAX. METER RESOLUTION ON MOST SENSITIVE RECOMMENDED NULL RANGE	
500	0.01 V	(10 mv)	0.005 V	(5 mv)
50	0.001 V	(1 mv)	0.0005 V	(500 uv)
5	0.0001 V	(100 uv)	0.00005 V	(50 uv)
0.5	0.00001 V	(10 uv)	0.000005 V	(5 uv)

STABILITY OF REFERENCE SUPPLY:

0.01% for change in line voltage (105 V to 130 V).

0.1% per hour after warmup (adjustable via front panel CAL control).

STABILITY OF METER ZERO:

4% of full scale for 20% change in line voltage.

2% per hour after warmup

CALIBRATION:

500 Volt reference supply calibrated against built-in standard cell.

INPUT POWER:

105 - 130 Volts, 60 cycles, 60 watts

1-3 GENERAL SPECIFICATIONS

DIMENSIONS:

9-3/4" wide x 13" high x 14" deep--standard model.

19" wide x 8-3/4" high x 16-3/4" deep--rack mounted model.

FINISH AND WEIGHT:

Smooth grey baked enamel. Grey baked wrinkle case.

Cabinet model--25 lbs.; rack mounted model--28 lbs.

SECTION II

INTRODUCTION

2-1 GENERAL DESCRIPTION

The Model 801H Precision Differential Voltmeter is a compact, highly accurate instrument designed for precise measurement of DC voltages. Ease of operation and inherent protection from accidental overload, combined with high accuracy and resolution, assure equal suitability for production line testing or precision laboratory measurements.

The Model 801H may be used as a vacuum tube voltmeter, as a differential DC voltmeter, or as a megger, i.e. for measuring high resistances. It is possible to make precise measurements of stable voltages, or to observe and measure voltage excursions about some nominal value.

When used as a precision DC voltmeter, the 801H operates on the potentiometric principal wherein an unknown voltage is bucked against an adjustable known voltage, and the difference read on a sensitive null detector. When zero displacement current flows in the null detector, the unknown voltage is exactly equal to the known voltage and the impedance presented to the unknown voltage source and null detector is infinite.

2-2 INSPECTION

This instrument has been thoroughly checked in the John Fluke Calibration Laboratory prior to shipment. Upon receipt of the instrument, inspect it carefully for any damage which may have neen incurred during transit. Refer to the Warranty Section of this manual if shipping damage is discovered.

2-3 POWER REQUIREMENTS

The Model 801H is normally supplied wired for 105 - 130 volt, 60 cycle operation.

SECTION III

OPERATING INSTRUCTIONS

3-1 CONTROLS AND TERMINALS

The following descriptions are intended to familiarize the customer with the basic use of the controls and terminals of the Model 801H Potentiometric DC Voltmeter. They are not intended as operating instructions. Refer to Section III, paragraph 3-2, before attempting to use the Model 801H for any purpose. Refer to paragraphs 3-3 through 3-7 for detailed operating instructions.

a. POWER switch

The POWER switch is the toggle switch located at the bottom of the instrument face. With the switch ON, the meter face and one of the decimal lights adjacent to the Kelvin-Varley dials will be illuminated, indicating that the primary circuit of the power transformer has been closed.

b. ZERO control

The ZERO control adjusts the meter deflection. The CAL switch must be in the REF position prior to zeroing the meter.

c. RANGE switch

The RANGE switch has four positions (500,50,5,0.5) and is used to select the range of the voltage to be measured.

d. CAL switch

The CAL switch has three positions: OPERATE, REF CAL, and ADJ CAL. When the switch is in the REF CAL position, the meter is removed from the VTVM circuit. When in the ADJ CAL position, the meter is placed in the circuit which compares a sample of the internal reference supply with the standard cell.

e. ADJ CAL control

The control is used to set the reference supply to an exact 500 Volts by varying the potential on the grid of V8.

f. NULL switch

The NULL switch determines whether the instrument is to be used as a VTVM or a differential voltmeter in one of the five null sensitivity ranges. In the VTVM position, the meter has a full-scale deflection equal to the value selected by the RANGE switch. The 10, 1, 0.1, 0.01, and 0.001 volt positions indicate the full-scale deflections of the meter when in one of the null ranges.

g. KELVIN-VARLEY dials

These dials enable the user to set up any voltage from 0 to 500 volts within the instrument in order to buck out the unknown voltage being measured. These dials are calibrated in volts to provide in-line readout with an illuminated decimal point.

h. INPUT terminals

Positive and negative terminals isolated from chassis ground and a chassis ground terminal with shorting link are provided. The three terminals are located on 3/4 inch centers and will accommodate a banana plug.

3-2 PRE-OPERATION CHECKS

a. To set up instrument and zero meter, proceed as follows:

(1) Connect instrument to 117 volt, 60 cycle source.

(2) Set RANGE switch to 500 position.

(3) Set NULL switch to VTVM position.

(4) Set all five voltage dials to zero.

(5) Set CAL switch to REF.

(6) Throw toggle switch to ON.

(7) When toggle switch is placed in ON position, the meter should light up, and a slight buzzing noise may be heard. (NOTE: Buzzing comes from a 60 cycle chopper used to achieve stable DC amplification in the null detector.)

(8) Allow the instrument to warm up for approximately five minutes.

(9) Adjust ZERO knob for meter zero.

b. Calibrate internal 500 volt reference supply.

(1) Ensure CAL switch is on REF and check the meter zero.

(2) Rotate and hold the CAL switch at ADJ position with the left hand, then turn the ADJ CAL knob with the right hand until the meter reads zero. (NOTE: When the meter needle is within one major scale division of zero, the reference supply will be set to 500 volts within 0.01%.)

(3) Turn the CAL knob to OPERATE. The instrument is now ready for use.

CAUTION: The model 801H has a 3-wire line cord with the third conductor (green) tied to the chassis. For personnel safety, this wire should be connected to a good earth ground. The positive binding post should not be connected to the chassis ground post before the instrument under test has been checked to insure that there is no conflict in the grounding of the circuit under test and the Model 801H.

3-3 MEASUREMENT OF DC VOLTAGES

a. Determine Approximate Value of DC Voltage:

(1) Set RANGE switch to 500 position, NULL switch to VTVM position; and connect the voltage which is to be measured to the plus and minus binding posts.

(2) If the meter reads to the left, reverse the connection; if not, continue to step (3).

(3) Set the RANGE switch to the lowest range which will give an on scale reading, i.e., if the voltage is 3.5 volts, set the RANGE switch to 5.

NOTE: With the NULL switch in the VTVM position, the 801H functions as a conventional 4 range VTVM with 10 megohms input resistance on all ranges. It is accurate to better than 3%. Although it may be utilized for general purpose use, it is intended in this instrument to give the approximate location of the unknown voltage in the 0 to 500 volt spectrum.

b. Determine Precise Value of Unknown Voltage

(1) Set the five voltage dials to the approximate voltage indicated on the meter. For example, if the meter indicated the unknown voltage to be approximately 3.5 volts, set the A knob to 3, the B knob to 5, and the C, D, and E knobs to 0.

NOTE: Be sure to observe the decimal light. If the range switch is set to the 5 volt position, the decimal light between the A and B knobs will be lit.

(2) Now turn the NULL knob to the 1 volt position, (The 10 volt position may be skipped when measuring voltages of less than 10 volts.) and adjust last four knobs (B,C,D, and E) for zero meter deflection.

(3) Turn the NULL knob to the 0.1 volt position and turn the last three knobs (C,D, and E) for zero meter deflection.

(4) Finally, turn the NULL knob to the 0.01 volt position and turn the last two knobs (D and E) for zero meter deflection.

(5) The unknown voltage may now be read directly from the five dials, accurate to 0.05% of the actual voltage.

3-4 MEASURING VOLTAGE EXCURSIONS ABOUT A NOMINAL VALUE

To observe excursions of a voltage about a nominal value:

a. Determine nominal value of voltage by following the steps outlined in Section 3-3, paragraph a.

b. Select appropriate NULL range and observe voltage excursions directly on the meter. A right hand deflection of the meter needle indicates that the voltage under observation has increased above the nominal value, a left hand deflection indicates that the voltage has decreased by the amount indicated.

3-5 USE OF RECORDER OUTPUT

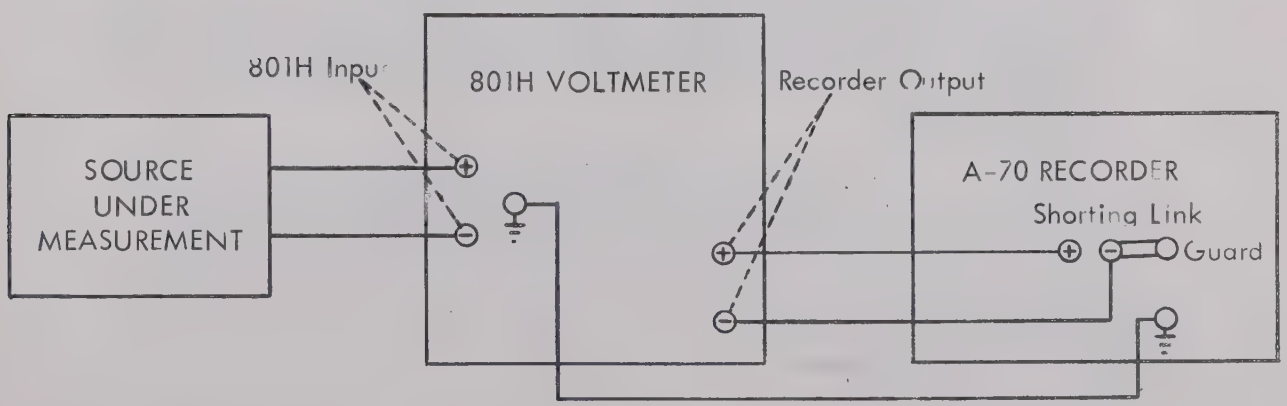
The Model 801H includes provisions for recorder monitoring or for recording the excursions of the unknown voltage from the voltage indicated by the dial settings.

WARNING
RECORDER REQUIREMENTS

NOTE ONE: The input of the recorder must be isolated from ground (see the following diagram). If the recorder input is grounded, current will be drawn from the 801H Kelvin-Varley divider and the accuracy of the Model 801H will be completely destroyed.

NOTE TWO: The leakage resistance between the recorder input and the ground must be greater than 5,000 megohms or the accuracy of the 801H will be impaired. Also, both input posts of the recorder should be able to stand 500 Volts DC to ground. Therefore, the John Fluke Mfg. Co. recommends that the John Fluke A-70 Potentiometric Recorder (manufactured by Texas Instrument Company) be used with the Model 801H. In all cases, good quality (polyvinyl or better) leads should be used to connect the Model 801H to the recorder.

* RECOMMENDED CONNECTION DIAGRAM



*If the recorder should be jittery, it is suggested that a 1,000 ohm resister be substituted for the shorting link

Model 801H
Differential Voltmeter

a. Connect Recorder

The output terminals at the rear of the Model 801H must be isolated from ground when connected to the recorder. Connect the recorder and make one or both of the following checks:

CHECK ONE:

(1) Connect a standard cell to the input of the 801H.

(2) Measure the standard cell potential.

(3) Alternately connect and disconnect the recorder leads at the rear of the 801H. If there is more than one-quarter of a small division deflection of the meter needle, leakage has been introduced by the recorder and the accuracy of the 801H will be impaired.

CHECK TWO:

(1) Zero the VTVM circuit.

(2) Set the RANGE switch to 500 Volts, turn all five voltage dials to zero, and place the NULL switch to the 1 Volt position.

(3) Turn the voltage dials to register 400 Volts. A properly operating 801H should show less than one-quarter of a small division deflection from zero as indicated on the meter. If there is more deflection, disconnect the recorder and repeat the operation to determine whether there is leakage in the VTVM circuit or whether leakage has be introduced by the recorder.

b. Operation

A signal of 25 millivolts maximum from the null detector is available at the recorder output posts at the rear of the Model 801H. This signal may be varied by means of the GAIN ADJ potentiometer immediately adjacent to these posts. Accordingly, the recorder deflection may be adjusted to suit the particular application involved.

For example, if it were desired that full-scale meter deflection would result in full-scale recorder deflection, the instrument could be set up as follows:

(1) Zero the meter on the 801H.

(2) Place NULL switch in 10 Volt range.

(3) Turn Kelvin-Varley dials to register 10 Volts.

(4) Short out 801H input posts in order to achieve full-scale meter deflection.

(5) Turn GAIN ADJ potentiometer on the back of the 801H until full-scale recorder deflection is achieved.

3-6 USE AS A CONVENTIONAL VTVM

As specified in Section 3-3, paragraph a-(3), the 801H will function as a conventional VTVM when the NULL switch is in the VTVM position and the RANGE switch is in either the 500, 50, 5, or 0.5 Volt position. In addition to these ranges, there are five other ranges available. These five ranges are 10, 1, 0.1, 0.01, and 0.001. The 10, 1, and 0.1 Volt ranges have a 10 megohm input resistance, whereas the 0.01 and 0.001 Volt ranges have a one megohm input resistance. The ranges are accurate within ±3%. To achieve these ranges:

a. Set all five voltage dials to zero.

b. Connect the voltage to be measured to the input binding posts.

c. Set the NULL switch to the desired voltage range.

NOTE: The RANGE knob is not used in this case and may be in any position.

3-7 MEASURE HIGH RESISTANCES (Use as a Megger)

The Model 801H may be used to measure resistances between 1 megohm and 500,000 megohms. The following equation is used when determining these resistances:

$$Rx = 10^7 \left(\frac{E}{EM} - 1 \right)$$ where:

Rx is the unknown resistance in megohms.
E is the voltage setting of the 5 voltage knobs.
EM is the meter reading on the appropriate scale (either 10-0-10 or 1-0-1) as determined by the NULL switch setting.
10^7 is the input resistance of the VTVM in the 10 and 1 Volt null ranges.

Consequently, to measure a high value resistance:

a. Set the RANGE switch to 500, and the NULL knob to either the 10V or 1V Position.

b. Zero the meter with the Zero knob.

c. Connect the unknown resistance between the plus and minus terminals. (NOTE: Leave the link between the minus terminal and ground connected. Use short, isolated leads as the 801H will measure the leakage resistance of the insulation on long leads.)

d. Adjust the five voltage controls to any desired value between 0.01 and 500 volts or to any voltage which allows convenient reading of the meter, i.e. produces a reasonable, easily read meter deflection.

Example: The maximum resistance that can be read is approximately 500,000 megohms. If this resistance were connected to the input posts, the NULL switch to the 1V position, and five voltage dials set to 499.910 the meter would read 0.01 volts to the left of zero.

e. Read the meter, the voltage dials, and the NULL switch setting; substitute these values in the above equation; and compute the resistance.

f. Resistances up to 5,000 megohms may be measured without using the formula:

(1) If the resistance is less than 500 megohms set the NULL switch to the 10 V position; adjust the five voltage knobs for full-scale meter deflection; and subtract 10 from the reading of the voltage dials. This gives the resistance in megohms.

(2) If the resistance is less than 5,000 megohms but more than 500 megohms set the NULL switch to the 1 volt position; adjust the five voltage dials for full-scale meter deflection; subtract 1 from the reading of the voltage dials; and multiply the difference by 10. This gives the resistance in megohms.

3-8 NOTES ON MEASURING DC VOLTAGES

a. General

Reference to the Model 801H specification sheet will show the recommended VOLTS RANGE switch setting for obtaining maximum accuracy from the instrument. Since the accuracy of the Model 801H is governed chiefly by the

linearity of the Kelvin-Varley five-dial attenuator, and since the highest accuracy resistors in the attenuator are used in the A and B decades (all resistors matched to ±0.005%) and the next highest accuracy in the C, D, and E decades (all resistors matched to ±0.025%), it is best to use these most accurate decades at all times.

For example, when measuring a voltage of 3.52 Volts, do so by setting the VOLTS RANGE switch to the 5 position and using all 5 knobs rather than setting the VOLTS RANGE switch to the 500 position and using only the last three knobs. Better absolute accuracy will thus be obtained.

Reference to the Model 801H specification sheet will also indicate certain recommended NULL ranges to be used with each setting of the VOLTS RANGE knob. The 0.01 Volt NULL range is not recommended for use in the 50 to 500 Volt range for three reasons. First, unless the voltage being measured is an even multiple of 0.01 Volts, it will be impossible to obtain a null, since the last voltage dial is calibrated in 0.01 Volt steps when operating in the 500 Volt position of the VOLTS RANGE switch; one step of this switch causes full-scale meter deflection with NULL Switch to 0.01 V. Second, it is unlikely that a voltage of say 450 Volts will be stable at 10 millivolts, and third, the Model 801H will tend to meter the regulation of its own 500 Volt reference supply. The regulation of this reference supply is approximately 0.01% for a 30% change in line voltage. While this figure is more than adequate for the instrument when used in recommended fashion, it may cause some meter rattle if the line voltage fluctuates badly while the instrument is used in the 0.01 Volt null range for metering excursions at several hundred Volts.

b. Effect of AC Component

Because of the filter at the input of the null detector, an AC component of several times the DC may be present on the DC signla being measured and the 801H will still read within specifications.

A triple section low-pass filter comprised of R232 through R234 and C214 through C216 is used at the input to reduce any AC present on the DC being measured. This filter has an attenuation of at least 66 db at 60 cycles. Accordingly, a one Volt 60 cycle component will be reduced to less than one-half millivolt. However, this may cause a reading of as much as 50% of full-scale when operating in the 0.001 Volt null range. If large AC components are present and the lowest null range must be used, external filtering may be required. If such filtering is used, the capacitors should be high quality units with extremely high leakage resistance.

c. Measurement of Negative Voltages

Voltages which are negative with respect to ground, as well as the more commonly encountered positive variety, may be measured with the 801H. However, when the 801H positive binding post is connected to the metal case, either at the posts themselves or at the source under measurement, and the negative side of the 801H is connected to the "hot" side of the source, certain circuit conditions are changed and must be taken into consideration.

> CAUTION: The Model 801H has a 3-wire line cord with the third conductor (green) tied to the chassis. For personnel safety, this wire should be connected to a good earth ground. The positive binding post should not be connected to the chassis ground post before the instrument under test has been checked to be sure that there is no conflict in the grounding of the circuit under test and the Model 801H.

First, a 1.0 mfd capacitor (C101) is connected directly across the source under measurement. In certain circuits this capacitance may affect the source EMF. If this capacitor were removed there would still be considerable capacity in the form of transformer winding capacitance and wiring strays between the 801H input posts.

Second, a small 60 cycle signal appears between the 801H input posts (across C101) when the plus post is tied to the metal case. This comes about by slightly unbalanced transformer high voltage winding-to core capacitances. By careful transformer design this signal has been kept to less than 50 millivolts. Never the less, it may still affect the 801H reading and/or the DC voltage under the following conditions:

(1) If the most sensitive null range (0.001 volt) is being used, a fraction of a millivolt may get through to the chopper contacts and appear as a DC off-null reading. If the DC voltage under measurement is quite small, some inaccuracy may result.

(2) If the source under measurement contains unilateral conducting elements such as the diodes used in limiter circuits, together with high internal resistance, this spurious 60 cycle signal may be rectified by these diodes and appear across the source as DC which either adds to or subtracts from the true EMF of the source. The 801H will of course read this false voltage. Therefore, if the source under measurement does contain diodes, choppers, or other unilateral circuit elements, some additional filtering may be necessary

to prevent this spurious 60 cycle signal from reaching the voltage source under measurement. A twin T is extremely effective and will reduce the signal to a few millivolts of 180 cycles, which can be handled with a simple low-pass filter if still objectionable. Or one or more sections of a low-pass filter alone may be used between the 801H and the source. The twin T has the advantage of low series resistance. This is only important if off-null voltage excursions are being observed. Since the 0.01 and 0.001 range input resistance is 1 megohm, series resistance of greater than 100 k may cause objectionable full-scale off-null error. At null, of course, the input resistance has no effect.

Third, connecting the positive post to chassis leaves C101, a 1.0 mfd capacitor, connected across the input. With nothing connected to the input posts and the NULL switch in the more sensitive null ranges, the meter will move erratically as the setting of the five voltage dials are changed. This comes about because C101 charges and discharges to the level set on the five voltage dials, through the input resistance of the VTVM channel (10 megohms for the 10, 1, 0.1, Volt ranges, and 1 megohm for the 0.01 and 0.001 Volt ranges). Since the entire change in voltage appears across the R in an RC circuit at the instant the change occurs, the meter needle will pin hard at the instant the voltage dials are changed (providing the change is greater than that required for full-scale meter deflection). Consequently, do not turn the voltage dials with the null switch in other than the VTVM position when the input is unterminated, since no useful purpose is so served anyway.

SECTION IV

CIRCUIT DESCRIPTION

4-1 GENERAL

The Model 801 H Precision Potentiometric DC Voltmeter operates on the potentiometric principle wherein an unknown voltage is measured by bucking it against an adjustable known voltage and the difference read on a sensitive null detector. When zero difference current flows in the null detector, the unknown voltage is exactly equal to the known voltage and the impedance presented to the unknown voltage source by the known voltage source and the null detector is infinite.

4-2 CIRCUIT DESCRIPTION

The circuitry consists of six main elements:

a. A regulated, extremely stable 500 Volt reference source.

b. Means for setting this reference source to 500 Volts within ±0.01%.

c. A range switch for dividing the 500 Volts down to three lower reference voltages (50, 5, 0.5 Volts).

d. A calibrated 5-decade Kelvin-Varley precision attenuator for dividing the reference voltage down to the exact level of the unknown voltage.

e. A calibrated multi- range VTVM which is used both as a conventional VTVM for determining the approximate value of the unknown voltage and also as a calibrated null detector for measuring the difference between the unknown voltage and the known voltage desired from the 5-decade calibrated attenuator.

f. Appropriate attenuator for reducing the signal input to the VTVM for the four VTVM ranges and the five null ranges (10V, 1V, 0.1V, 0.01V and 0.001V).

The 500 Volt reference source consists of an unregulated 900 Volt DC supply (V1, R10, C1A,B,C, R40, R41, R42), a pre-regulator delivering 625 Volts at 1% regulation (V2, V3, V4, and associated components), and a super-regulator delivering 500 Volts at 0.01% regulation (V5, V6, V7, V8, and associated components). The super-regulator uses the highly stable type OG3 reference tubes, a carefully balanced differential amplifier, and precision wirewound resistors.

The 500 Volt reference source is calibrated by a standard cell (B1). A precision wirewound divider (R33, R34, R35, and R36) is placed across the 500 Volt supply and derives a sample voltage equal to the EMF of the standard cell when the output of the 500 Volt supply is exactly 500 Volts. CAL switch section S104A connects the difference between the standard cell and the sample voltage to the null detector. To calibrate, turn the S104 CAL switch to ADJ and rotate the ADJ CAL knob until there is zero deflection of the meter needle.

The RANGE switch consists of S102B and S102C, precision wirewound resistors R120 through R130, and rheostats R124, R126, and R129. The 200,000 ohm five-dial Kelvin-Varley attenuator shunts the output of the range switch.

The five-decade Kelvin-Varley precision attenuator is made up of S105 through S109, and associated matched precision wirewound resistors R131 through R179. The resistors

in the A and B switches are matched to within ±0 005% of each other, while those on the C, D, and E switches are matched within ±0.025%.

NOTE: If any of the resistors in the dial attenuator become defective, send resistor value and instrument serial number to John Fluke Mfg. Co. Inc. A record is kept of the exact resistor values in each instrument shipped. Consequently a replacement can be obtained which will not upset the matching of the other resistors on the particular switch.

The combination VTVM/null detector consists of a chopper amplifier (V203 through V205 and associated components), the meter (M101), and null switch sections S103A, B, and C

The detector has a basic full-scale sensitivity of 0.001 Volts in the 0.001 Volt null position, the REF CAL position, and the ADJ CAL position. It is switched to 0.01 Volt sensitivity by S103D for all other null and V VM ranges. Resistors R105 through R110 attenuate the input when the null switch S103B is in the VTVM position, and R112 through R116 attenuate the input when the switch is in any of the null ranges. V201 and V202 and associated circuitry provide regulated positive and negative supply voltages, and Q201 and Q202 and associated circuitry provide regulated filament power for V203 through V205.

The gain of the null detector is stabilized by a feedback network consisting of R212, R213, R214, and R215 so that 1 millivolt or a 10 millivolt DC signal (depending on the position of S103D) applied to the null detector input will drive the meter, M101, to full scale.

A low-pass filter serves to reject the unwanted AC from the DC signal input. The reed and upper contact (pin 6) of the chopper amplifier convert the DC signal to square wave AC and V205 and the two halves of V204 amplify it. After amplification, the AC output signal is synchronously rectified by the reed and lower contact (pin 1) of the chopper.

R220 and C206 form a low pass filter for removing the ripple component from the rectified signal, and after the removal of the ripple component, the resulting DC signal is applied to cathode follower V203. V203 drives the meter and feedback resistors, R212, R213, R214 and R215. The DC feedback voltage appears on the reed of the chopper and is compared with the input DC to produce the error signal.

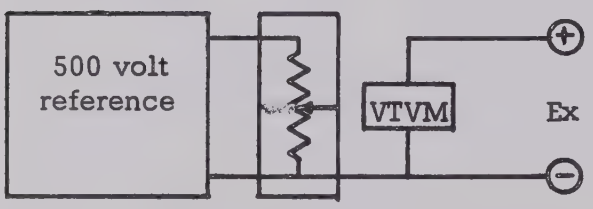
The attenuators for reducing the signal input for the four VTVM ranges and the five null ranges consist of the appropriate sections of NULL switch S103 and resistors R112 through R116. Range switch section S102E and resistors R105 through R110 divide the unknown voltage down to 0.01 Volts from either 500, 50 5, 0.5 Volts depending on the settings of the switch.

When the instrument is used as a straight VTVM the negative input binding post is connected to the negative side of the voltmeter channel via NULL switch S103A. The posi-

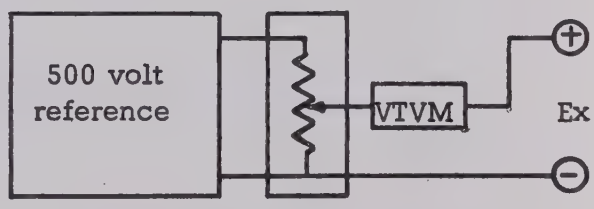
tive input binding post is connected to the RANGE switch divider via NULL switch S103B and the VTVM input is connected to the output of the RANGE switch divider via the NULL switch S103C and CAL switch section S104B (see the following diagram).

When the instrument is used in the differential mode, the entire voltmeter channel is floated between the output of the five-dial attenuator and the positive input binding post (see the following block diagram.). This i effected via NULL switch sec ion S103A.

Capacitor C102 (1 mfd, 600 V) in the 500 Volt position and C103 (1 mfd, 200 V) in the 50, 5, and 0.5 Volt positions are used to eliminate noise picked up by the wirewound resistors in the five-dial attenuator and provide a return path to the negative binding post for the chopper input filter.



5 Dial
Attenuator
STRAIGHT VTVM



5 Dial
At enuator
DIFFERENTIAL VTVM

SECTION V

MAINTENANCE

5-1 GENERAL CLEANING

The Model 801H is extremely sensitive to the slightest amount of electrical leakage from the VTVM channel, particularly from the input grid of V205 (pin 1) and all its associated wiring to the negative side of the input. Leakage resistance of 40,000 megohms between this grid circuit and the negative input will cause a 10% left meter deflection in the 1 volt range when the voltage dials are set to 400 volts. Lower values of leakage resistance will cause larger meter deflections.

It is therefore necessary that the instrument be cleaned occasionally to remove dust and foreign matter. Particular attention should be paid to the nylon nuts which insulate the VTVM chassis from the metal frame of the instrument and to the positive binding posts and the ceramic NULL RANGE switch.

To clean, proceed as follows:

a. Blow out the instrument with a low-pressure air hose (be sure air is dry) and wash off with a clean, dry rag.

b. If necessary, wash switches with a small, stiff-bristled brush dipped in Metriclene solvent M-4 (manufactured by the John B. Moore Company, Nutley, New Jersey). This is a high grade non-toxic solvent made for use on all delicate electrical equipment. Many other solvents have very poor electrical properties and leave a residue which may be slightly conductive. (NOTE: Do not use Metriclene to clean binding post insulators).

c. After washing, coat ceramic surfaces with a 10% solvent of Dow Corning 200 Fluid (100 viscosity grade) in Metriclene. This prevents moisture from collecting on the ceramic surfaces.

d. If it should be necessary to clean the binding post insulators, do not use Metriclene. Use only pure denatured alcohol and a clean cloth, as the insulator materials are slightly solvent in Metriclene.

NOTE: If the instrument is stored for any considerable period of time in a hot, humid atmosphere, considerable leakage may be noticed upon initial operation. This is evidenced by large meter offsets in the null ranges as the voltage dial settings are increased. Normally this will clear up as the instrument warms up and dries out. If not, remove the instrument from the case and wipe the above mentioned surfaces with a clean, dry cloth.

5-2 TUBE REPLACEMENT

The circuits in the Model 801H are so designed that tube and transistor selection is not necessary. If a particular tube type, such as the OG3, voltage reference tube, or the 9-7, ballast tube, is not available locally, the John Fluke Manufacturing Company Sales Representative in your area should be contacted and advised of the tube type required.

5-3 STANDARD CELL REPLACEMENT

The standard cell (B1) used in the Model 801H is an Eppley type MIN 1. This is a miniature low hysteresis unit which has excellent long term stability and negligible temperature hysteresis. (NOTE: Hysteresis is a temporary increase in EMF immediately following a decrease in temperature. This effect should not be confused with temperature co-efficient.)

Under normal conditions the standard cell should last from 8 to 15 years. The end of life usually is noticed by a marked increase of temperature hysteresis effect, i.e. reading errors in excess of 0.05% will result when the same voltage is read with the 801H hot or cold. Should replacement of the cell be necessary for any reason, the instrument must be recalibrated (see Section 5-5), since the EMF of different cells may be different by

as much as 0.05% and each instrument is calibrated to its own particular standard cell. The nominal EMF of a new Eppley type MIN 1 cell at average room temperature is 1.0193 volts.

NOTE: Do not subject the standard cell to below freezing temperatures, as the electrolyte will freeze at - 17 degrees Centigrade and operation below 0 degrees Centigrade is definitely not recommended. Furthermore, it should be noted that the life of the standard cell will be greater if the 801H is not operated at elevated temperatures. The 8 to 15 year figure stated above applies to operation of the instrument in normal room temperature ambients.

5-4 TROUBLESHOOTING

The following chart list various trouble symptoms, possible causes, and/or remedies. It is recommended that tube substitution be tried before any other tests are made. If tubes known to be good do not clear the trouble, voltage and resistance measurements should then be made.

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
Excessive Drift in 500 Volt Reference Supply	This is normally shown by the need to recalibrate the instrument every 5 to 10 minutes. The trouble is usually caused by one of the following: 1. A defective reference tube (V6 or V7). 2. A faulty equating tube (V8). 3. A leaky feedback capacitor (C12).
Excessive Drift in VTVM	The drift should stop after a few minutes operation. If it does not, replace the V205.
Inability to Calibrate Instrument	If meter deflection cannot be reduced to zero by the steps outlined in paragraph 3-2 of Section III, the trouble is in one of the following areas:

SYMPTON	CAUSE AND/OR POSSIBLE REMEDY
	1. Either R30, R31, or R32 has shifted, making it impossible to bring the output of the super-regulator to 500 Volts. Rotate R31 until instrument can be calibrated.
	2. V6 and/or V7 have aged to the point where their running voltage is too low. This voltage should be from 85 to 87 volts. If it is possible, replace the defective tubes. Screwdriver adjust control R31 may be adjusted to bring the ADJ CAL control to the approximate center of rotation when the meter deflection has been reduced to zero. Only add a resistor under emergency conditions and then use only a precision wirewound resistor wired with either Evenohm, Karma, or Manganin alloys. DO NOT UNDER ANY CONDITIONS ATTEMPT REPLACEMENT WITH ORDINARY POWER RESISTORS, NICHROME RESISTORS, CARBON OR DEPOSITED CARBON RESISTORS, OR ANY METAL FILM RESISTORS. THIS STATEMENT APPLIES TO EVERY PRECISION WIREWOUND RESISTOR IN THE INSTRUMENT.
	3. One of the three wirewound resistors (R33, R34, R35) in the standard cell sampling string has changed value. If replacement of any of these resistors is necessary, the instrument must be recalibrated.

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
	4. The standard cell may have shifted value. The cell should measure between 1.0190 Volts and 1.0196 Volts. The standard cell must be measured with a precision potentiometer such as the John Fluke Model 801 or the Leeds & Northrup Type K potentiometer. DO NOT USE A VOLT-OMETER. If replacement of the cell is necessary, the 801H must be recalibrated. 5. The rectifier filter (V1 and C1A, B, C), the super-regulator power supply (V5, V6, V7, and V8), or the pre-regulator (V2, V3, and V4) has failed. The output of the rectifier filter should be approximately 900 Volts at a line voltage of 117 Volts. The output of the pre-regulator should be from 610 to 640 Volts and be regulated to better than 1% over a range of 100 to 130 Volts line. The output of the super regulator must be 500 Volts and should have a range of adjustability of ±5 Volts. Regulation in this case must be 0.01% or better for a line voltage range of 100 to 130 Volts.
Error in Excess of Specified Values	This is caused either by the instrument being out of calibration or by a defective resistor in the five-dial Kelvin Varley voltage divider. 1. To determine whether the divider is satisfactory, proceed as follows: a. Set the five voltage dials to 400.00 and apply an EMF from a stable, high resolution power supply such as the John Fluke Models 301C, 406, or 407.

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
	b. Adjust the power supply until a null is obtained in the 1 Volt range. c. Remove the voltage from the input and reset the five voltage dials to 399.910. d. Reconnect the 500 Volts to the input NULL switch in the 1 Volt position. The meter should null within 80 millivolts (0.02%). e. Repeat this check by applying 50 Volts and setting up 50.00 on the voltage dials and then 49.910. A difference in the two readings must be less than 25 millivolts (0.05%). 2. If it appears that the five-dial Kelvin-Varley Voltage Divider is satisfactory, check to determine whether the instrument is in calibration. There are four calibration adjustments. The basic adjustment concerns the 500 Volt range and is adjusted by screwdriver adjust rheostat R36. This adjustment affects not only the 500 Volt range, but the 50 Volt, 5 Volt, and the 0.5 Volt ranges as well. The lower three ranges are adjusted by individual adjustment rheostats, R124, R126, and R129, respectively. These three adjustments are completely independent in that they have no effect on each other nor on the 500 Volt adjustment (R36). In checking the calibration, the 500 Volt range must be the first consideration, as if this is out of calibration all three

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
	lower ranges will also be out. To check the 500 Volt range perform the calibration operation as outlined in paragraph 3-2, Section III. Then apply a known 500 Volt (this source must be accurate to 0.01% or better) to the instrument and measure it. The Kelvin-Varley dials must read between 499.90 and 500.10 Volts, (#±0.02%). If it reads outside of these limits, see the following recalibration instructions: **NOTE: A 500 Volt EMF accurate to 0.01% is extremely difficult to obtain. If there is any doubt as to the accuracy of the 500 Volt, DO NOT USE IT. Instead, contact the John Fluke Field Representative in your area, as he will usually be able to provide an approved precision calibration set-up. Refer also to the recommended calibration set-up in this manual.** If the error appeard in one of the three lower voltage ranges, but the basic 500 Volt calibration was found to be off and recalibration performed, reset the lower range that was in error to determine whether the recalibration of the 500 Volt range corrected the error. If not, proceed as follows: a. Assuming the error appeared in the 5 Volt range, set the RANGE knob to the 5 Volt position.

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
	b. Apply a known 5 Volts (this voltage must be accurate to 0.01% or better) to the instrument and measure it. c. The Kelvin-Varley dials should read between 4.999 and 5.001 Volts (±0.03%). If it reads outside of these limits, see the following recalibration instructions: NOTE: As stated above, if there is any doubt as to the accuracy of the input voltage, contact the John Fluke Field Representative in your area for an approved precision calibration set-up.
Error in the VTVM Reading	1. If the error is in the VTVM and all NULL ranges, adjust the 10 millivolt gain (R212). 2. If the error is in the 0.001 range only, adjust R212. 3. If the error is in the VTVM range only, check the divider resistor. NOTE: DO NOT USE A SHARP POINTED TOOL AROUND THE SWITCH DIVIDERS. IF A DEPOSITED CARBON RESISTOR COATING IS SCRATCHED DEEPLY ENOUGH, THE RESISTOR WILL OPEN.
Meter needle offsets to the left as voltage dial settings are increased, i.e. NULL switch in 1 Volt position, RANGE switch in 500 Volt position, and nothing connected to input posts	This normally indicates that there is leakage between the positive post and ground. See paragraph 5-1, "General Cleaning," for a description of this.

SYMPTON	CAUSE AND/OR POSSIBLE REMEDY
Excessive error which appears only at low voltages when operating in the 1 Volt NULL range.	This normally is caused by defective wirewound resistors on S108 or S109. See the previous troubleshooting paragraph regarding Kelvin-Varley non-linearity.
Meter needle wobble with signal applied.	The trouble may be in: (1) the source under measurement; (2) in the bucking voltage developed in the 801H; or (3) in the VTVM circuit. To check the first two possibilities, apply an absolutely steady voltage and see if the wobble ceases. If it does, the trouble was in the source under measurement. If the wobble is still present, remove the signal from the input posts. If wobble is still present, the trouble is in the VTVM. If it disappears the trouble is either in the 500 Volt reference supply, the Kelvin Varley Divider, or if operating in other than the 500 Volt range one of the three range dividers. To track down trouble in the 500 Volt reference supply, use another ℱ Model 801H, 801, or 800 and monitor the output of the 500 Volt reference on the defective 801H. If the 500 Volts is steady, the trouble is in the Kelvin-Varley dividers or the range dividers. If the 500 Volts is not stable, the trouble may be: (1) R30, R32, or R24; (2) any of the tubes in the supply; (3) problems in the 650 Volt pre-regulator; or (4) a leaky feedback capacitor (C12).
Meter needle wobble with no signal applied.	This is usually caused by a microphonic 12AU6 (V205) or defective regulator tube (V201, or V202). Occasionally this wobble will appear only periodically; at a low frequency rate of perhaps once a second and at an amplitude equal to one small scale division. This is often caused by a defective regulator tube (V201 or V202) and occasionally by V205.

SYMPTOM	CAUSE AND/OR POSSIBLE REMEDY
Inability to bring meter needle to zero.	This may require adjustment of 218, which is used to center R117, the front panel zero control.
Meter offset when switching from 0.001 V to 0.01 V on NULL range.	Check mechanical zero.

5-5 RECALIBRATION INSTRUCTIONS

If it has been definitely determined that the instrument is out of calibration, proceed as follows: (NOTE: See paragraph 5-6 for recommended calibration set-up.)

a. Calibrate basic 500 Volt range.

(1) Apply a known 500 Volts (accurate to 0.01% or better) to the instrument.

(2) Set the five voltage dials to 499.910 and turn the NULL switch to the 1 Volt position.

(3) Zero the meter by adjustment of the ADJ CAL control.

(4) Withdraw the instrument part way from the case to gain access to R36, the screwdriver adjust control located at the botton of the large printed circuit board.

(5) Hold the CAL knob in the ADJ CAL position and check the meter for zero deflection.

(6) Adjust R36 until there is no meter needle deflection.

NOTE: This operation should be performed in a draft-free room since a strong draft across the wirewound resistors in the various dividers could cause some slight error.

(7) When meter needle deflection has definitely been eliminated, apply a small amount of Duco Household Cement to R36.

b. Calibrate 50, 5, and 0.5 Volt ranges.

(1) Ensure that the 500 Volt range is calibrated as it effects the lower ranges.

(2) Apply a known voltage equal to the full-scale value of the range being calibrated, i.e. for the 5 Volt scale apply a known 5 Volts accurate to within 0.01%, and set the NULL switch to the 0.01 volt position.

(3) Withdraw the instrument part way from the case so as to gain access to R124, R126, and R129, the range adjustment rheostats located on the printed circuit board mounted to the back of the Kelvin-Varley switch tray. R124 adjusts the 50 Volt range, R126, the 5 Volt range, and R129 the 0.5 Volt range.

(4) Adjust the R126 until the meter reads zero. The 5 Volt range is now in calibration.

NOTE: A very effective independent check of the entire instrument (particularly of the 5 Volt range) consists of measuring the EMF of a standard cell which has been certified by your own standards group. This furnishes a known EMF which will read out nicely on all five dials in the 5 Volt range. Measure this cell with the 801H--it should read well within ±0.03% of the certified value.

5-6 RECOMMENDED CALIBRATION SET-UP

The following block diagram shows the equipment recommended for final calibration of Ⓕ Models 800, 801, or 801H. This includes:

a. An Eppley Standard Cell (#100A)

b. A Leeds and Northrup Galvo (#2430A)

c. An ESI #194 precision voltage divider built by Electro Measurements, Inc., in Portland, Oregon.

d. A Ⓕ Model 310C or 301E Precision Meter Calibrator.

e. One coarse and one fine monentary push-button type switch with silver contacts.

The heart of this set-up is the precision voltage divider. This divider is so constructed that when the left hand knob is set to the exact EMF of the Eppley standard cell shown at the extreme left and the 301C output controls are adjusted until the Leeds and Northrup galvo comes to NULL with both the COARSE and FINE buttons pushed, the EMF applied to the precision divider will be 500 Volts within ±0.005%. The precision of this divider is such that the three divided down EMF'S (50, 5, and 0.5 Volts) will also be accurate within ±0.005%.

> NOTE: These figures are obtained at 72 degrees F. The accuracy will be maintained within ±0.01% providing room temperature does not deviate more than ±5 degrees F. from this figure.

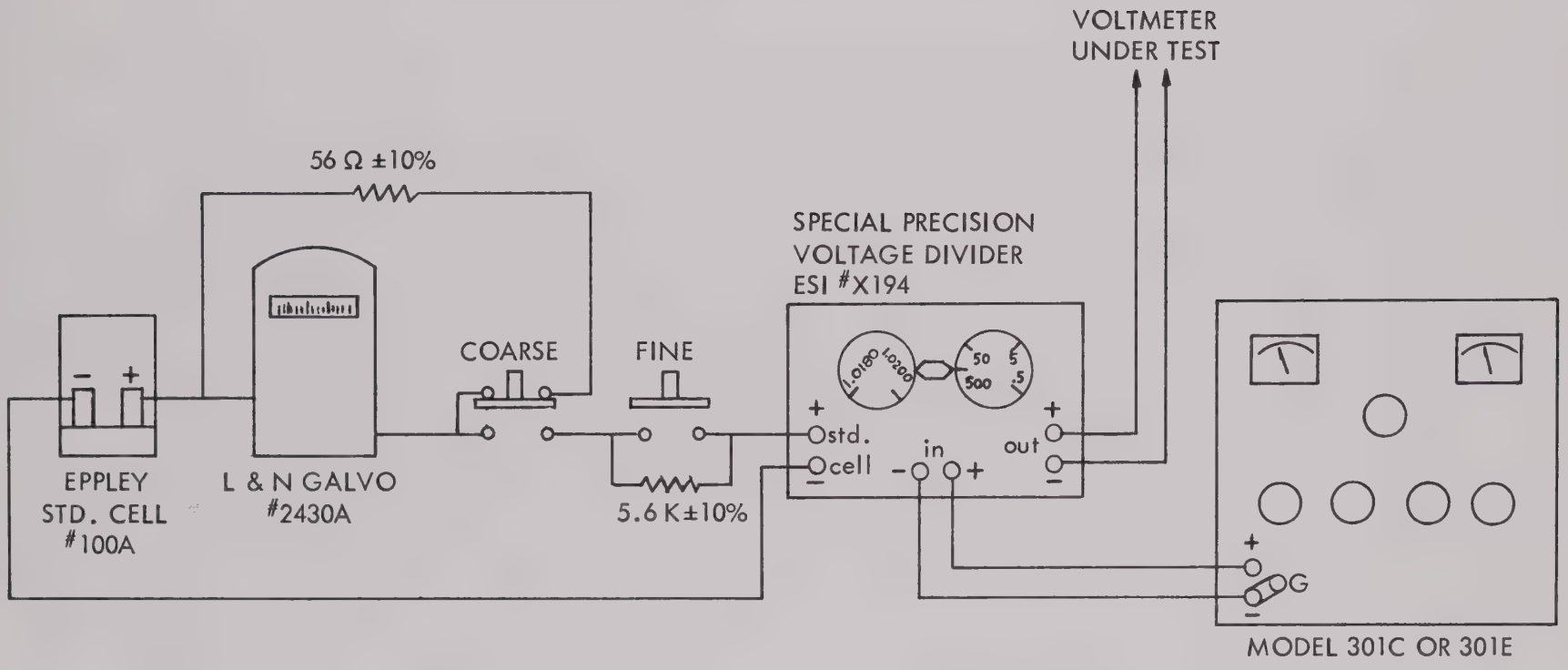
For this set-up to be accurate, it is necessary that the EMF of the particular standard cell being used to be known to an accuracy of ±0.002%. Accordingly, certification by some group which has a bank of saturated standard cells is required.

The Eppley Model 100A standard cell is encased in a special phenalic housing which is thermally insulated and lagged. It is recommended that it be further lagged by housing it in an aluminum box within a wooden box with 3 inches of glass wool between the cell and the aluminum box and the aluminum box and the wooden box.

While the Eppley 100A cell is of the unsaturated type which the Bureau of Standards will certify only to 0.01%, it will maintain an extremely constant EMF if treated with care and not subjected to sudden temperature changes. Many standards groups will read this cell's EMF down to the fifth place. If this value is used in setting the standard cell knob of the ESI divider and the cell is treated with care, the accuracy will normally be within ±0.002% (20 parts of a million) of the true EMF of the cell. Assuming this, the overall accuracy of the system will then be ±0.005% plus or minus 0.002% or somewhere between 0.003% and 0.007%, which is adequate for calibrating a 0.05% instrument.

TEST EQUIPMENT SET-UP FOR

FINAL CALIBRATION OF MODEL 800 SERIES VOLTMETER



COARSE & FINE SWITCHES ARE MOMENTARY PUSH BUTTON TYPE SHOWN IN NORMAL UNDEPRESSED POSITION. SINCE THESE SWITCHES ARE IN THE STANDARD CELL CIRCUIT THEY MUST HAVE FINE SILVER CONTACTS.

SECTION VI
LIST OF REPLACEABLE PARTS

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
B1	Standard cell, non-saturated, low hysteresis	X223
C1A, B, C	Capacitor, electrolytic, 20 mfd, 450 v	CE65
C3	Capacitor, paper, 0.01 mfd, 600 v	CP7
C10	Capacitor, paper, 0.1 mfd, 600 v	CP5
C11	Capacitor, paper, 0.1 mfd, 400 v	CP4A
C12	Capacitor, paper, 0.1 mfd, 1600 v	CP1
C13	Capacitor, ceramic disc, 0.002 mfd, 1 kv	CT8

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
C14	Capacitor, paper, 0.1 mfd, 600 v	CP5
C15	Capacitor, electrolytic, 15 mfd, 6 v	CE36
C101,102	Capacitor, paper, 1.0 mfd, 600 v	CP26
C103	Capacitor, polystyrene, 1.0 mfd, 200 v	CO22
C201	Capacitor, electrolytic, 10/10 mfd, 200 v	CE13
C202,203	Capacitor, electrolytic, 16 mfd, 450 v	CE3
C204	Capacitor, electrolytic, 40 mfd, 6 v	CE32
C206	Capacitor, mylar, 1.0 mfd, 280 v	CF5
C208A,B	Capacitor, electrolytic, 10/10 mfd, 450 v	CE13
C209,210,211	Capacitor, ceramic disc, 0.01 mfd, 500 v	CT18
C212	Capacitor, ceramic disc, 0.05 mfd, 500 v	CT19
C213	Capacitor, mylar, 0.01 mfd, 400 v	CF1
C214,215,216	Capacitor, polystyrene, 0.047 mfd, 100 v	CP29
C217	Capacitor, electrolytic, 2000 mfd, 25 v	CE25
R1	Resistor, power, 10Ω, ±5%, 5 w	R10WA
R10	Resistor, composition, 390Ω, ±10%, 1 w	GB3911
R11	Resistor, composition, 470 k, ±10%, 1/2 w	EB4741
R12-19	Resistor, composition, 22 k, ±10%, 2 w	HB2231
R20	Resistor, deposited carbon, 500 k, ±1%, 2 w	DR620
R21	Resistor, deposited carbon, 144 k, ±1%, 1 w	DR67

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R22	Resistor, composition, 39 k, ±10%, 1 w	GB3931
R23,25,180,29, 226,223,228	Resistor, composition, 1 m, ±10%, 1/2 w	EB1051
R24	Resistor, wirewound, 149 k, ±0.05%, 1 w	PR611
R26,27	Resistor, deposited carbon, 300 k, ±1%, 1 w	DR614
R28	Resistor, deposited carbon, 250 k, ±1%, 1 w	DR613
R30	Resistor, wirewound, 320 k, ±0.05%, 1 w	PR614
R31	Potentiometer, wirewound, 10 k, ±10%, 1/4 w	P10KB
R32	Resistor, wirewound, 158 k, ±0.5%, 1 w	PR620
R33,34	Resistor, wirewound, 125 k, ±0.1%, 1 w	PR610
R35	Resistor, wirewound, 509 Ω, ±0.1%, 1/2 w	PR37
R36	Resistor, wirewound, 5 Ω, ±20%, 2 w	P5A
R37,39	Resistor, composition, 47 k, ±10%, 2 w	HB4731
R38	Potentiometer, composition, 50 k, ±10%, 2 w	P50KC
R40 - 42	Resistor, composition, 220 k, ±10%, 1 w	GB2241
R101	Resistor, composition, 270 Ω, ±10%, 1 w	GB2711
R105	Resistor, deposited carbon, 9.9 m, ±1%, 1 w	DR79
R106	Resistor, deposited carbon, 253.2 k, ±1%, 1/2 w	DR631
R107	Resistor, deposited carbon, 900 k, ±1%, 1/2 w	DR622
R108	Resistor, deposited carbon, 90 k, ±1%, 1/2 w	DR513
R109	Resistor, deposited carbon, 9 k, ±1%, 1/2 w	DR412

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R110	Resistor, deposited carbon, 1 k, ±1%, 1/2 w	DR41
R112	Resistor, deposited carbon, 1 m, ±1%, 1/2 w	DR71
R113	Resistor, deposited carbon, 9 m, ±1%, 1 w	DR78
R114	Resistor, deposited carbon, 900 k, ±1%, 1/2 w	DR622
R115	Resistor, deposited carbon, 90 k, ±1%, 1/2 w	DR513
R116	Resistor, deposited carbon, 10 k, ±1%, 1/2 w	DR51
R117	Potentiometer, composition, 1 m, ±10%, 2 w	
	Model 801H	P1MA
	Model 801HR	P1MB
R 9	Potentiometer, wirewound, 1 k, ±10%, 2 w	P1KA
R120, 121	Resistor, wirewound, 112.375 Ω, ±0.05%, 1 w	PR615
R122	Resistor, composition, 27 k, ±10%, 1 w	GB2731
R123	Resistor, wirewound, 28.571 Ω, ±0.05%, 1/2 w	PR515
R124, 126, 129	Potentiometer, wirewound, 500 Ω, ±10%, 1/2 w	P500TA
R125	Resistor, wirewound, 2531.7 Ω, ±0.05%, 1/2 w	PR49
R127	Resistor, wirewound, 22.5 k, ±0.1%, 1/2 w	PR513
R128	Resistor, wirewound, 250.31 Ω, ±0.05%, 1/2 w	PR311
R130	Resistor, wirewound, 24.75 k, ±0.1%, 1/2 w	PR514
R131 thru 136	Resistor, wirewound, 40 k, ±0.02%, 1/2 w matched	PR512
R137 thru 147	Resistor, wirewound, 8 k, ±0.05%, 1/2 w matched	PR48
R148 thru 158	Resistor, wirewound, 1.6 k, ±0.1%, 1/2 w matched	PR46
R159 thru 169	Resistor, wirewound, 320 Ω, ±0.1%, 1/2 w matched	PR39
R170 thru 179	Resistor, wirewound, 64 Ω, ±0.1%, 1/2 w matched	PR24

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R181	Resistor, composition, 470 K, ±10%, 1 W	EB6831
R201, 202	Resistor, composition, 100 Ω, ±10%, 1/2 W	EB1011
R203, 204	Resistor, power, 5 K, ±5%, 4 W	R5KX
R205, 206	Resistor, power, 3.5 K, ±5%, 4 W	R3.5KX
R207, 208	Resistor, deposited carbon, 144 K, ±1%, 1/2 W	DR67
R209, 210	Resistor, deposited carbon, 1.845 K, ±1%, 1/2 W	DR45
R211	Potentiometer, wirewound, 500 Ω, ±10%, 2 W	P500A
R212, 218	Potentiometer, wirewound, 1 K, ±10%, 2 W	P10KA
R213	Resistor, deposited carbon, 10 K, ±1%, 1/2 W	DR51
R214	Resistor, deposited carbon, 1 K, ±1%, 1/2 W	DR41
R215	Resistor, deposited carbon, 150 Ω, ±1%, 1/2 W	DR37
R216	Resistor, composition, 0.470 K, ±10%, 1/2 W	EB4731
R217	Resistor, composition, 390 Ω, ±10%, 1/2 W	EB3911
R219	Resistor, composition, 22 K, ±10%, 2 W	HB2231
R220	Resistor, composition, 2.2 M, ±10%, 1/2 W	EB2251
R221,222,224	Resistor, composition, 100 K, ±10%, 1/2 W	EB1041
R225	Resistor, composition, 33 K, ±10%, 1/2 W	EB3331
R227	Resistor, composition, 150 K, ±10%, 1/2 W	EB1541
R229	Resistor, composition, 220 K, ±10%, 1/2 W	EB2241
R230	Resistor, composition, 10 M, ±10%, 1/2 W	EB1061

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R231 thru 234	Resistor, deposited carbon, 750 k, ±1%, 1/2 w	DR621
R235	Resistor, deposited carbon, 2.7 k, ±1%, 1/2 w	DR415
R236	Resistor, deposited carbon, 20 k, ±1%, 2 w	DR523
DS-101-104	Lamp, neon	X40B
F1	Fuse, 2 amp	F2
G201	Chopper, spdt, 6.3 v, 60 cycles	X100
CR1,2	Diode, 400 v, 300 ma	
CR201 thru 206	Diode, silicon, 600 v, PIV, 0.75 amp	RE17
Q201	Transistor, power	2N301W
Q202	Transistor, PNP, Germanium	2N1372
M101	Meter, 100-0-100 ma	M32
V-1	Vacuum tube, rectifier, 5AR4	5AR4
V-2	Vacuum tube, pentode, 6AQ5A	6AQ5A
V-3	Vacuum tube, pentode, 6AU6	6AU6
V-4	Vacuum tube, voltage regulator, OA2	OA2
V-5,203	Vacuum tube, duo triode, 12AU7	12AU7
V-6,7	Vacuum tube, voltage reference, OG3	OG3
V-8	Vacuum tube, duo triode, 12AX7	12AX7
V-9	Vacuum tube, current regulator, 9-7	9-7
V-201,202	Vacuum tube, voltage regulator, OB2	OB2
V-204	Vacuum tube, duo triode, 12AT7	12AT7

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
V-205	Vacuum tube, pentode, 12AU6	12AU6
VR-1	Lamp, Neon	X40B
T-1	Transformer	801-601
S101	Switch, toggle, DPST	ST1
S102	Switch, rotary, 6 pole 2-6 position	SR-29
S103	Switch, rotary, 5 pole 2-6 position	801H-804
S104	Switch, rotary 3 pole, 4 position	803R-804
S105	Switch, rotary 2 pole, 5 position	SR40
S106, 107, 108	Switch, rotary, 2 pole, 10 position	SR41
S109	Switch, rotary 1 pole, 11 position	SR42
	Knob, 1-1/2" without pointer	X207
	Knob, 1-1/2" with pointer	X234
	Knob, 1" with pointer	X231
	Lens, plexiglass	X354
	Connector, 24 pin, male	X255
	Connector, 24 pin, female	X254
	Binding post, red insulators	X219, 217
	Binding post, black insulators	X219, 218

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
	Binding post, metal spacer	X219,220
	Dial, voltage readout	D3
	Cord, power	X27D
	Strain relief, power cord	X138
	Feet, rubber mounting	X224
	Handle assembly	X373
	Fuse Holder	X12
	Washer, insulating, flat	X93
	Washer, insulating, shoulder	X93A
	Screw, nylon	X159
	Nut, nylon	X160

SECTION VII

WARRANTY

7-1 GENERAL

The John Fluke Mfg. Co., Inc., warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to their factory for that purpose, and to making good at their factory any part or parts thereof; except tubes, fuses, choppers, and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser to them with transportation charges prepaid, and which on their examination shall disclose to their satisfaction to have been thus defective.

If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

a. Notify us, giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, we will give you service data or shipping instructions.

b. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

7-2 SHIPPING

All shipments of John Fluke Mfg. Co., Inc., instruments should be made via Railway Express prepaid. The instrument shoud be shipped in original packing carton, or if not available, any suitable container that is rigid. If substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

7-3 CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt of same. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include Model number, type number, and serial number when referring to this instrument for any reason.

Do not hesitate to contact us concerning any questions which you may have about this instrument. The John Fluke Mfg. Co., Inc., will be happy to answer all application questions.

WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

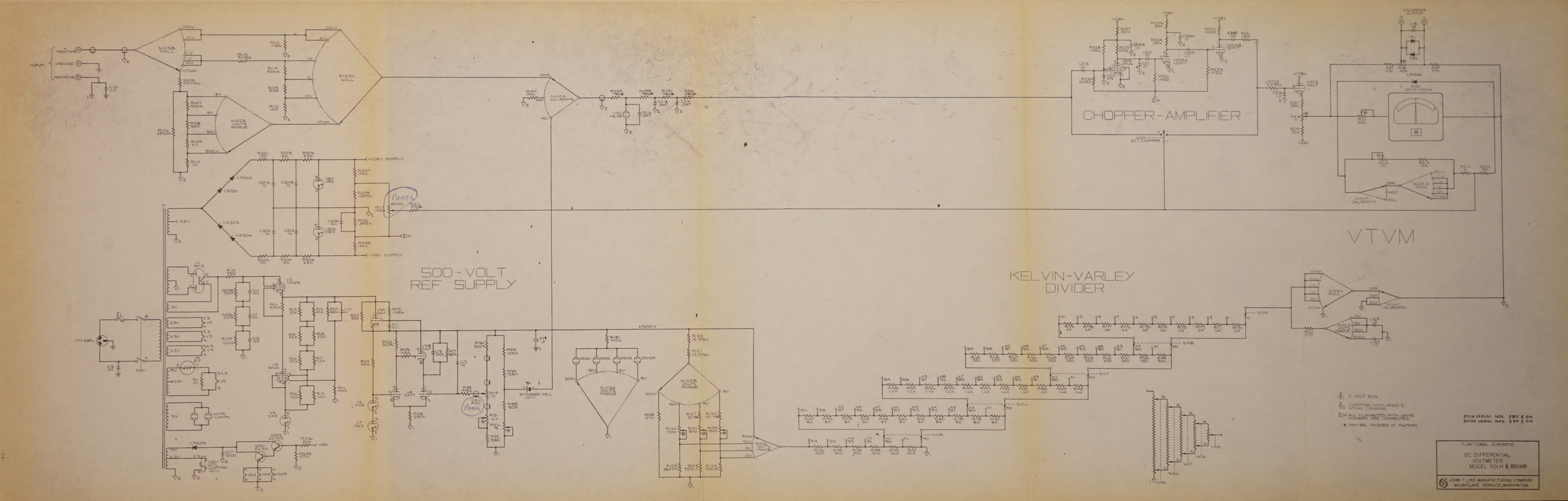
All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON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